(12) UK Patent Application (19) GB (11) 2 378 200 (13) A

(43) Date of A Publication 05.02.2003

(21) Application No 0217887.9

(22) Date of Filing 01.08.2002

(30) Priority Data
(31) 60310293 (32) 03.08.2001 (33) US

(71) Applicant(s)
Smith International, Inc.
(Incorporated in USA - Delaware)
16740 Hardy Street, Houston, Texas 77032,
United States of America

(72) Inventor(s)
James A Simson

(74) Agent and/or Address for Service
W H Beck, Greener & Co
7 Stone Buildings, Lincoln's Inn, LONDON,
WC2A 3SZ, United Kingdom

(51) INT CL^7
E21B 33/05 33/068 33/14 33/16

(52) UK CL (Edition V)
E1F FJS FJT

(56) Documents Cited
US 6182752 B
US 4854383 A
US 4345651 A
US 3076509 A

(58) Field of Search
UK CL (Edition T) E1F FJS FJT FJU FKD FKE FKF FKU
INT CL^7 E21B 23/00 33/05 33/13 33/14 33/16
Other: Online: WPI EPODOC JAPIO

(54) Abstract Title

Apparatus and method and swivel for cementing a string of tubulars in a borehole

(57) Apparatus (200) and method for cementing a string of tubulars in a borehole which comprises an enclosure (210,220,230) having a bore (214,224,234) therethrough, a sphere canister (260) having a sphere aperture (264) therethrough, a sphere valve member (270) having a hold position in which said sphere aperture (264) is closed and a drop position in which said sphere aperture (264) is open, and a sphere (295) disposed in said sphere aperture (264). The sphere valve member (270) closes said sphere canister (260) to flow in said hold position and opens said sphere canister (260) to flow to release said sphere (295) in said drop position. A dart canister (240) is also provided in which a releasable dart (290) is disposed. A swivel (900) for cementing a string of tubulars in a borehole has an outer stationary member (920) with cement connections (940), and an inner rotating member (910) with a bore (905) therethrough. The outer stationary member (920) is formed from one piece. Also an assembly which comprises a swivel and a cementing manifold and further an apparatus for cementing tubulars in a borehole which comprises three launching units.

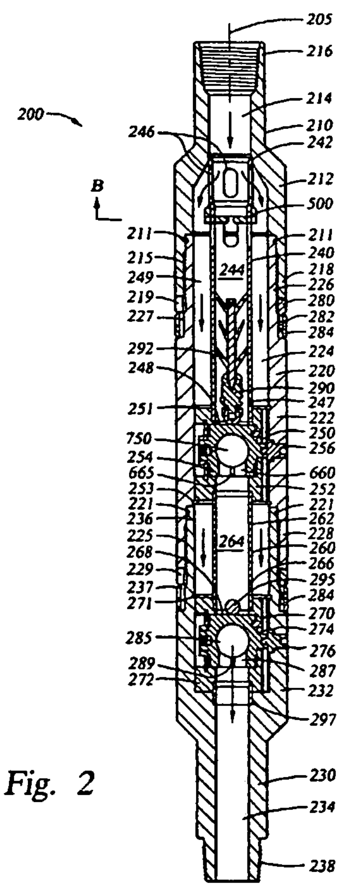


Fig. 2

BEST AVAILABLE COPY

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 378 200 A

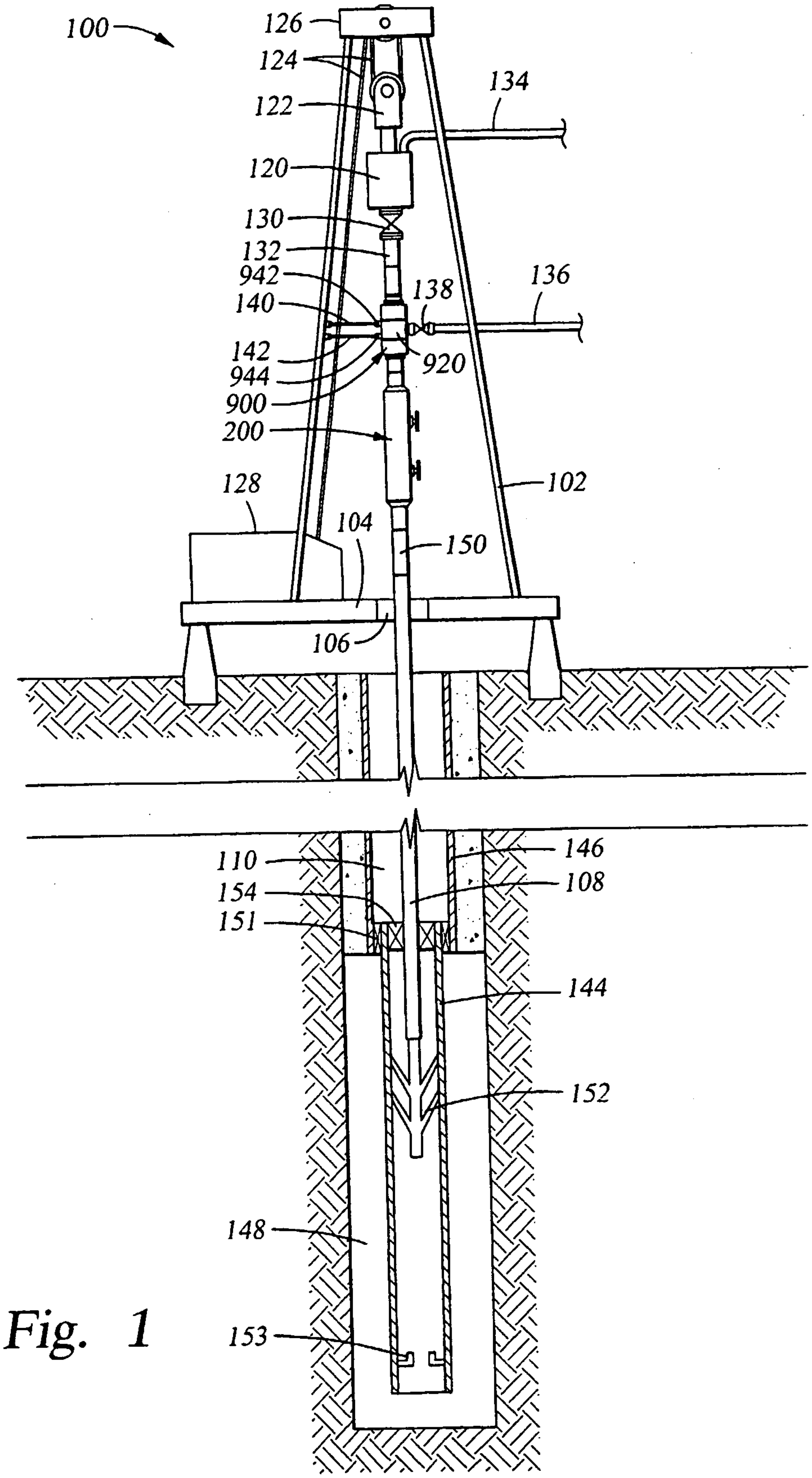

100
126
124
122
134
120
130
132
942
140
138
136
142
944
920
900
200
128
102
104
150
106
110
146
154
108
151
144
152
148
153

Fig. 1

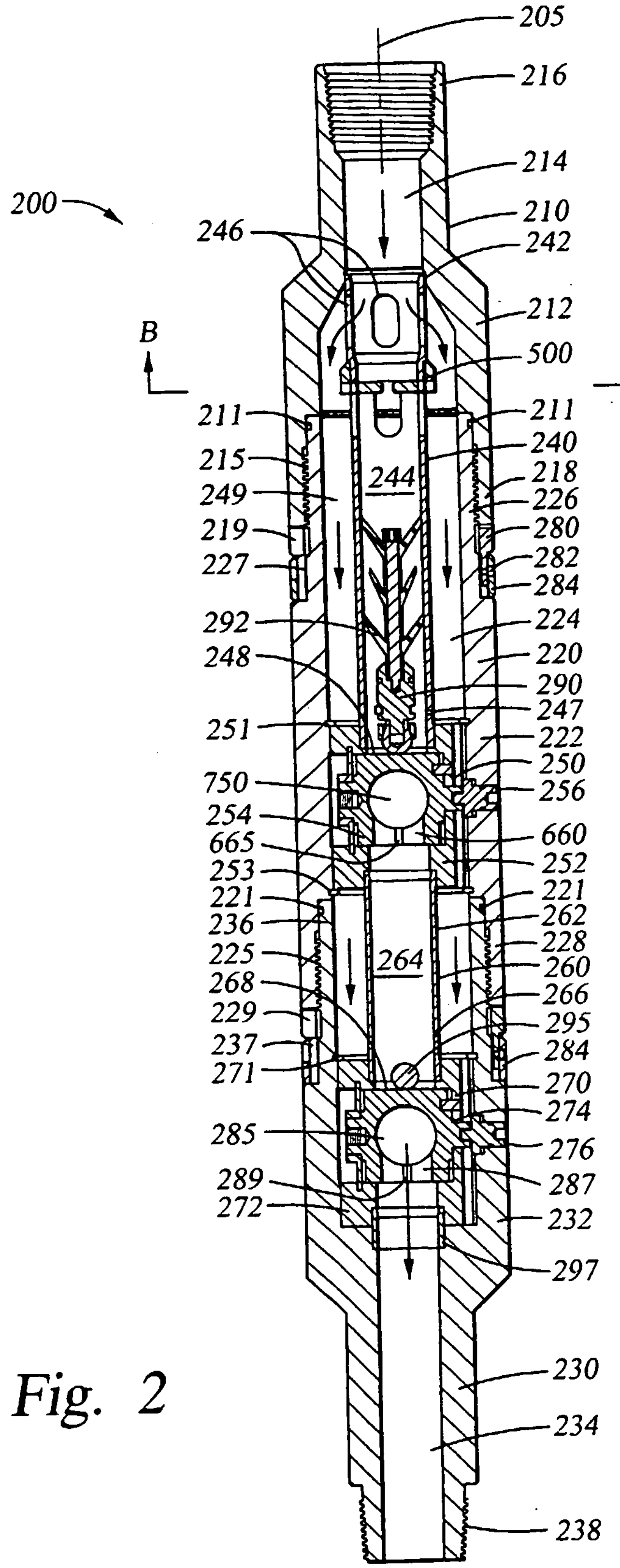

205
216
214
200
210
246
242
212
B
B
500
211
211
240
215
244
218
249
226
219
280
227
282
284
292
224
248
220
290
251
247
222
250
750
256
254
660
665
252
253
221
221
236
262
225
228
264
268
260
266
229
295
237
284
271
270
274
285
276
289
287
272
232
297
230
234
238

Fig. 2

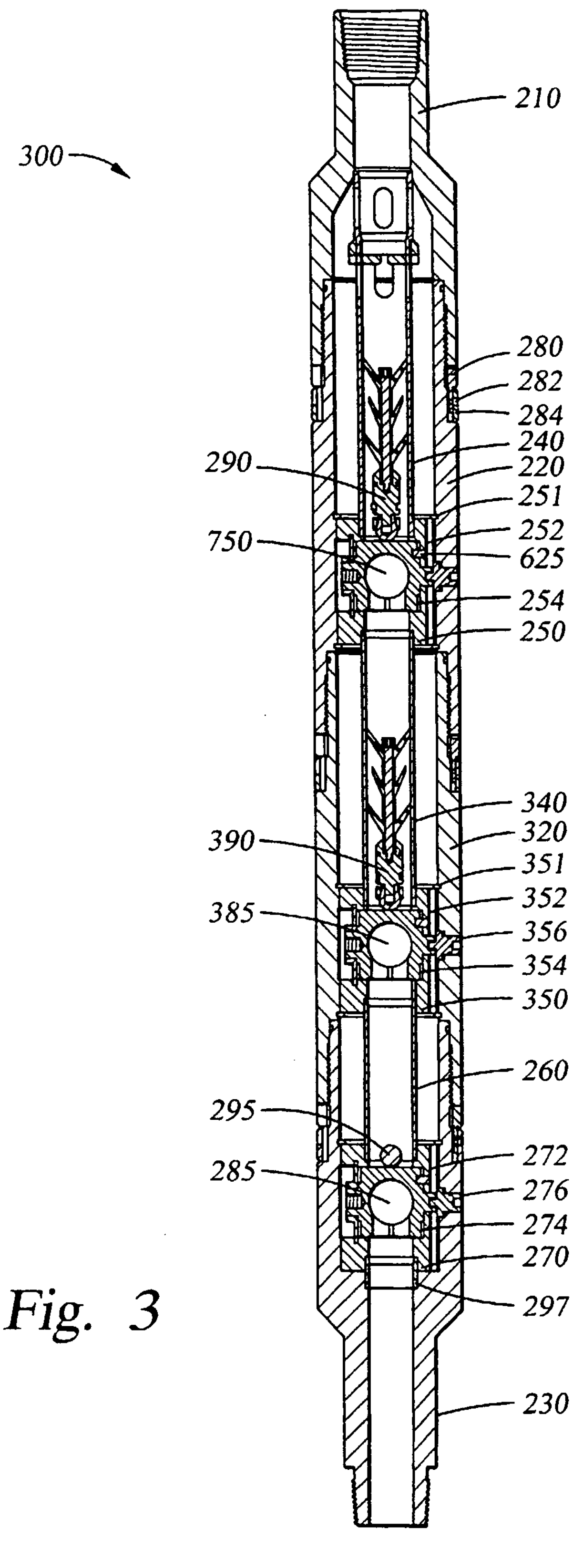
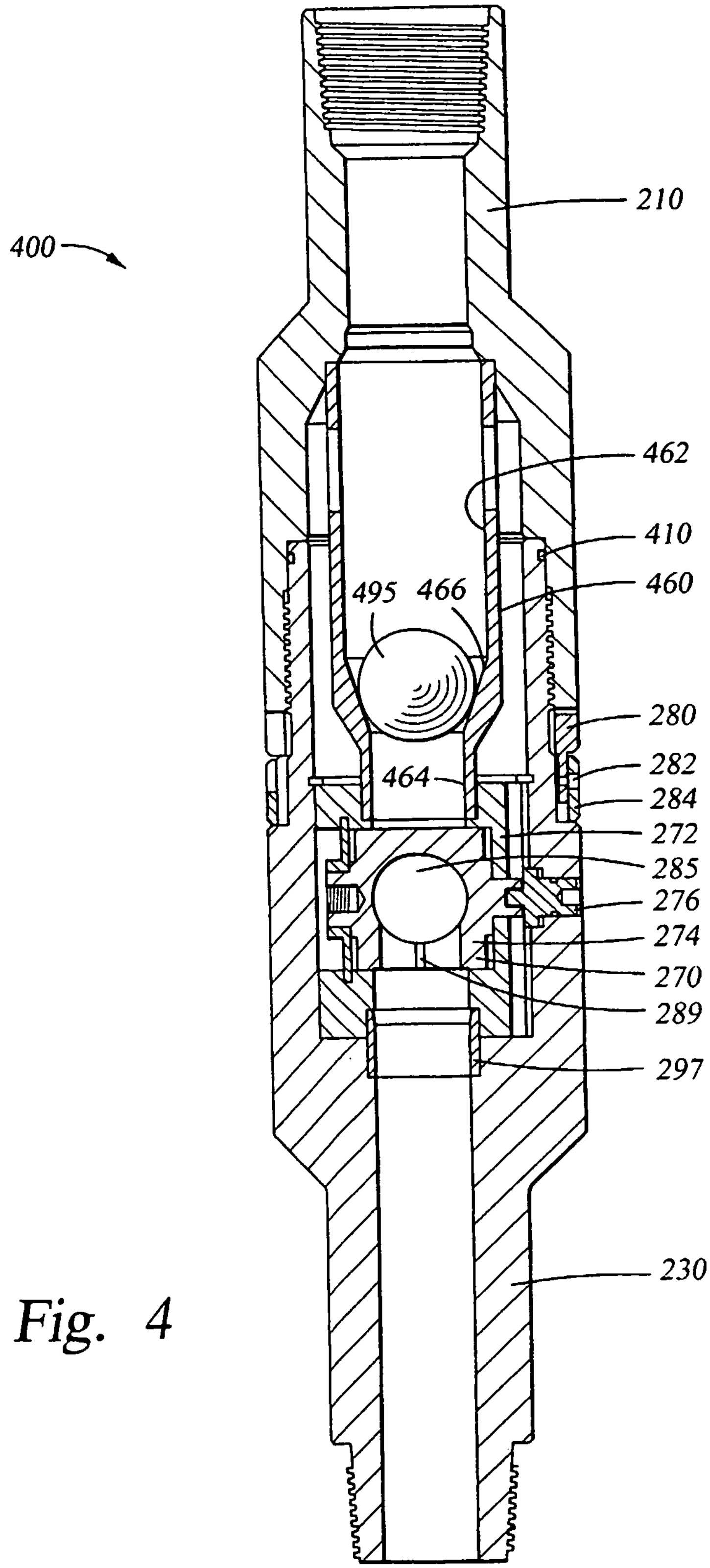

300
210
280
282
284
240
220
290
251
252
750
625
254
250
340
320
390
351
352
385
356
354
350
260
295
272
285
276
274
270
297
230

Fig. 3



400
210
462
410
460
495
466
280
282
464
284
272
285
276
274
270
289
297
230

Fig. 4

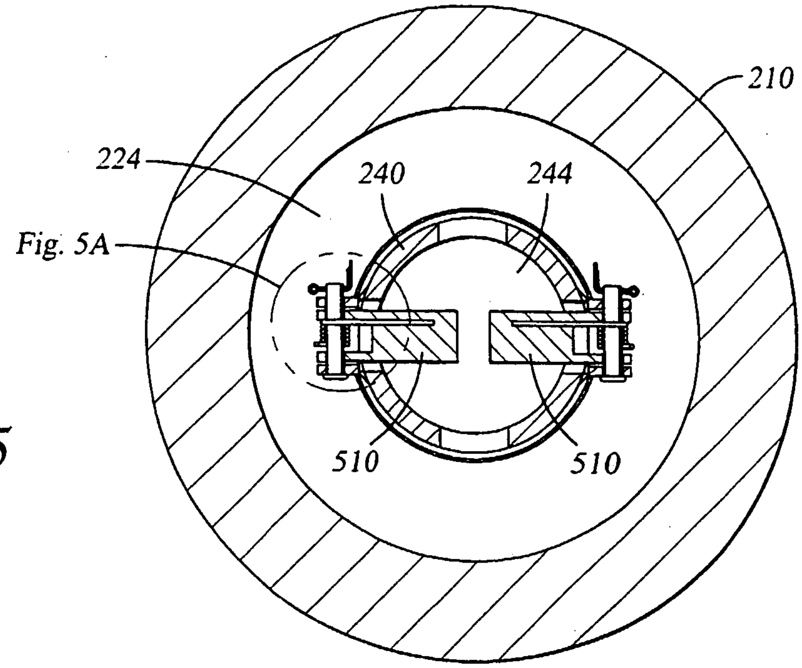


Fig. 5

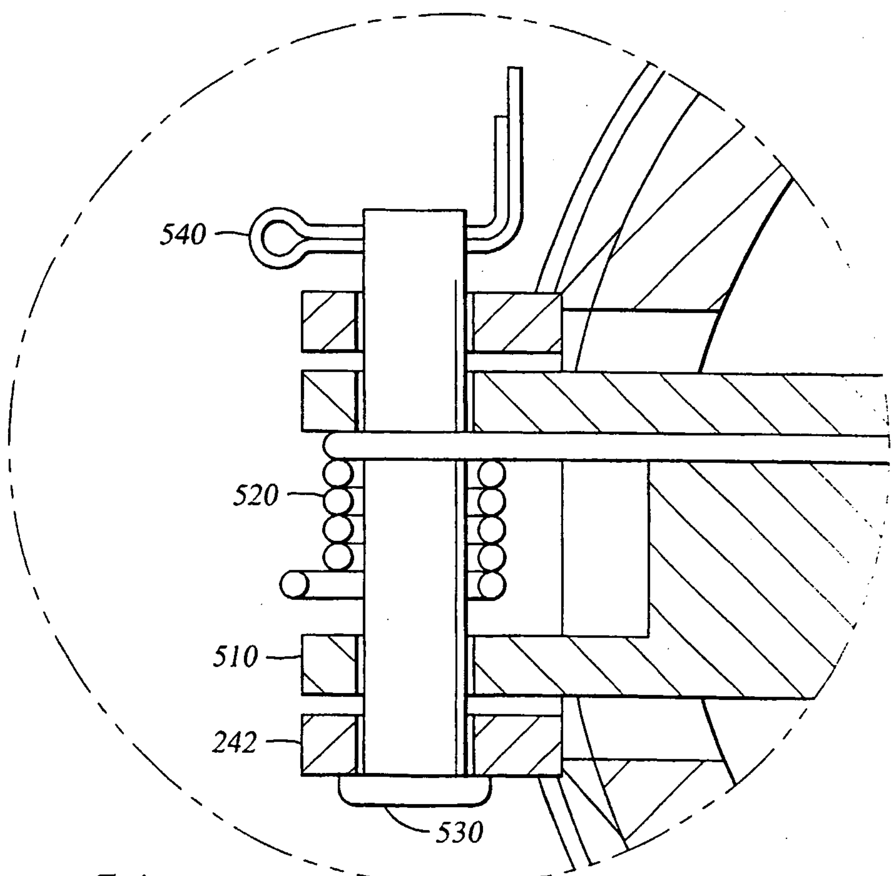


Fig. 5A

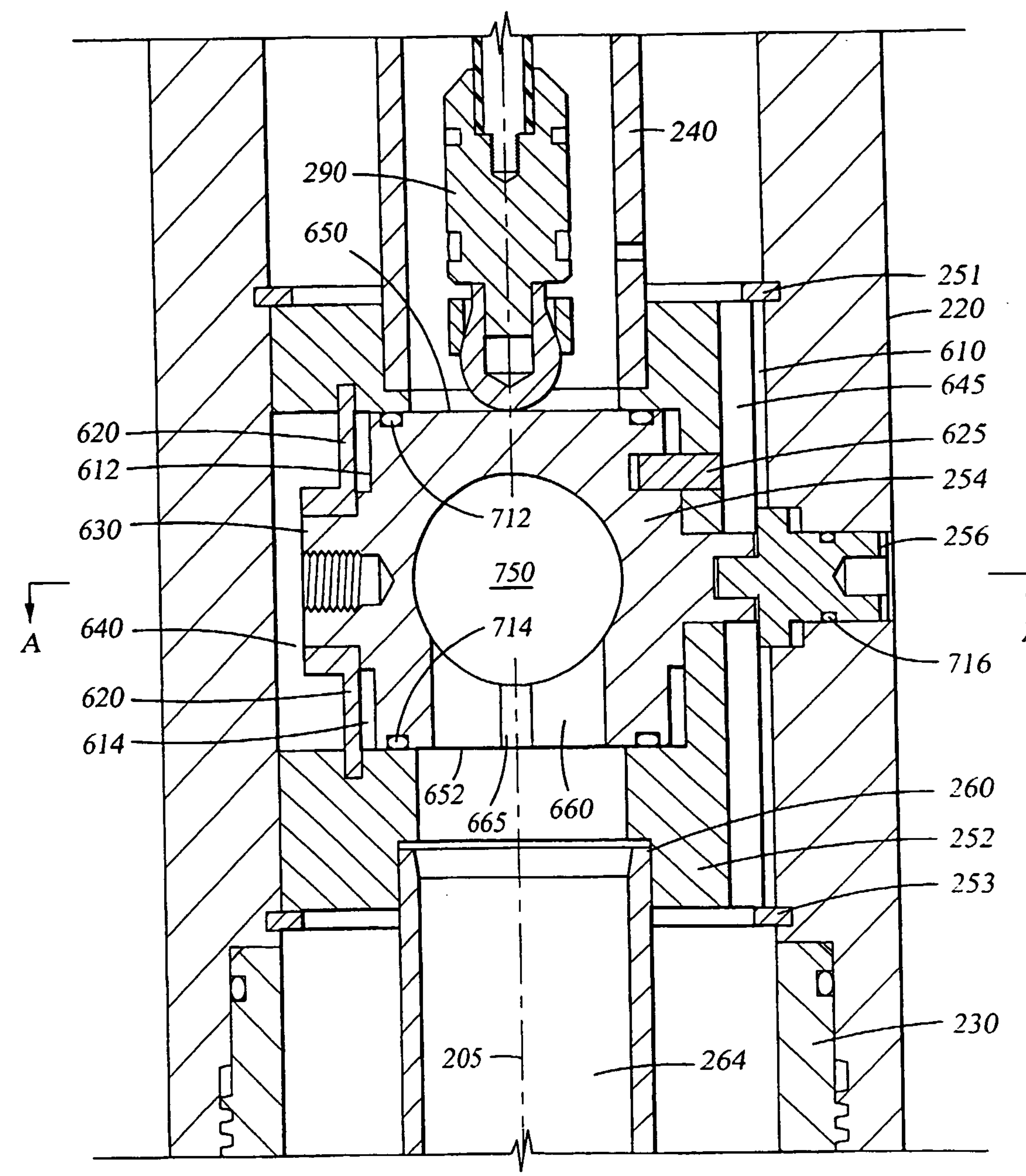

240
290
650
251
220
610
645
620
612
625
254
630
712
256
750
A
640
714
A
716
620
614
260
652
665
660
252
253
230
205
264

Fig. 6

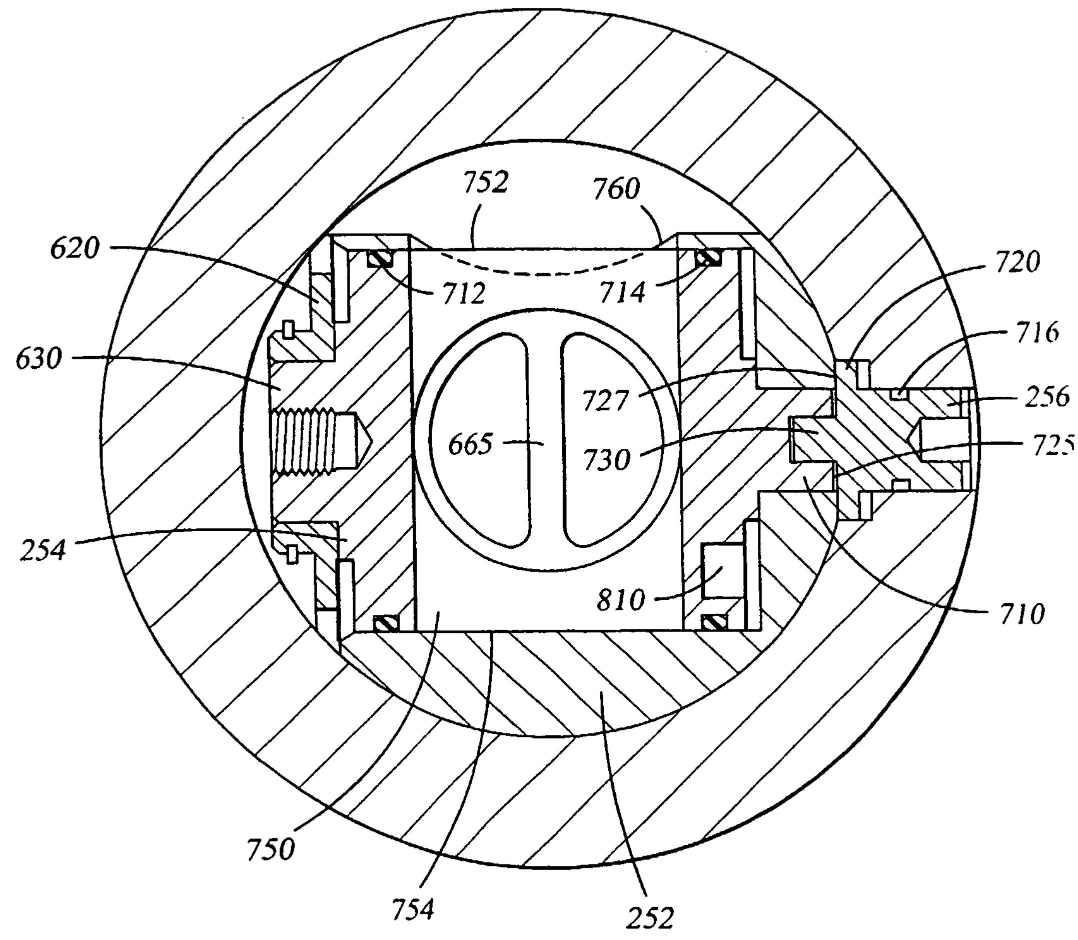

752
760
620
712
714
720
716
630
727
256
665
730
725
254
810
710
750
754
252

Fig. 7

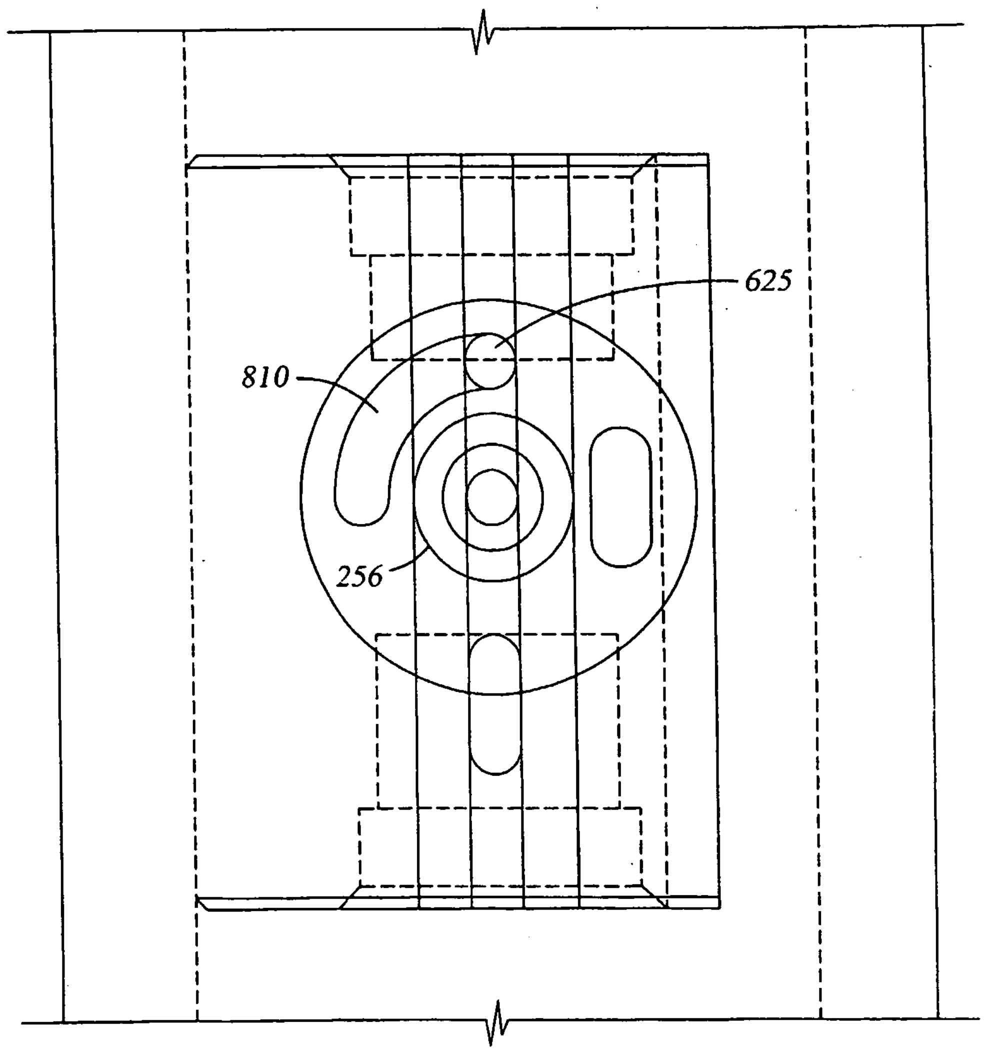


Fig. 8

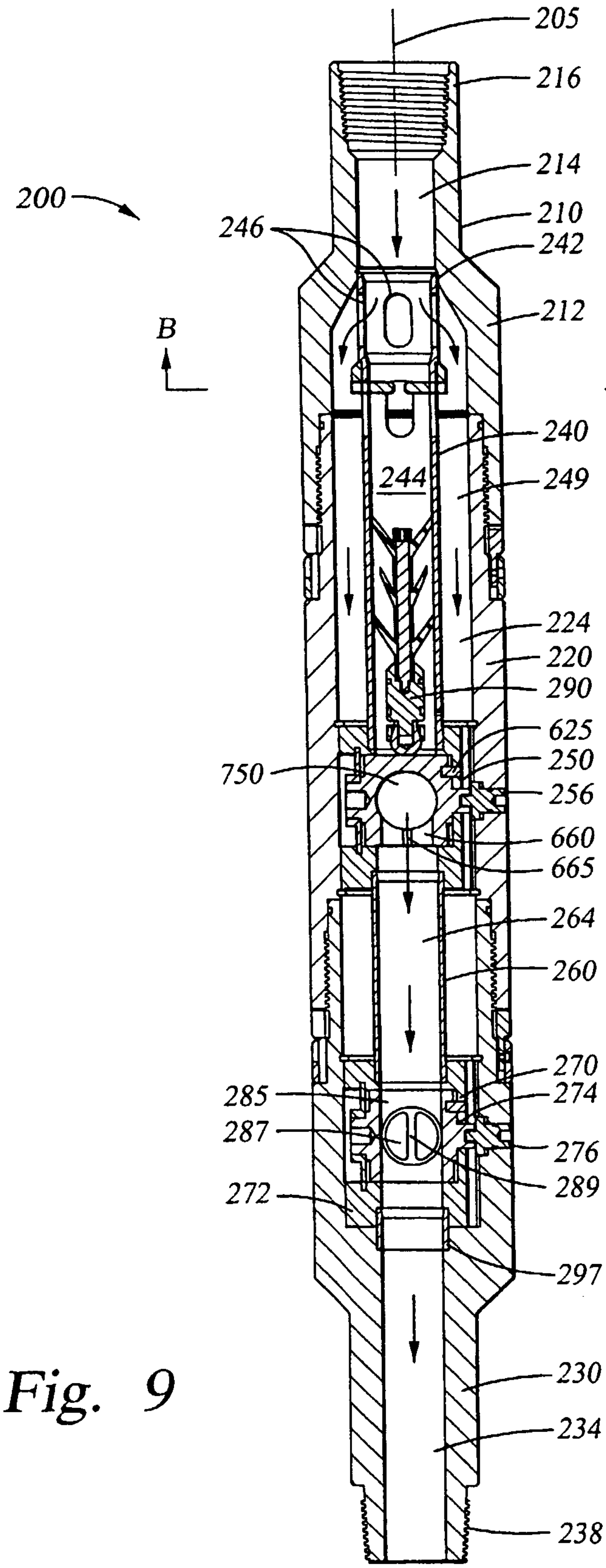

205
216
214
200
246
210
242
212
B
B
240
244
249
224
220
290
625
750
250
256
660
665
264
260
270
285
274
287
276
289
272
297
230
234
238

Fig. 9

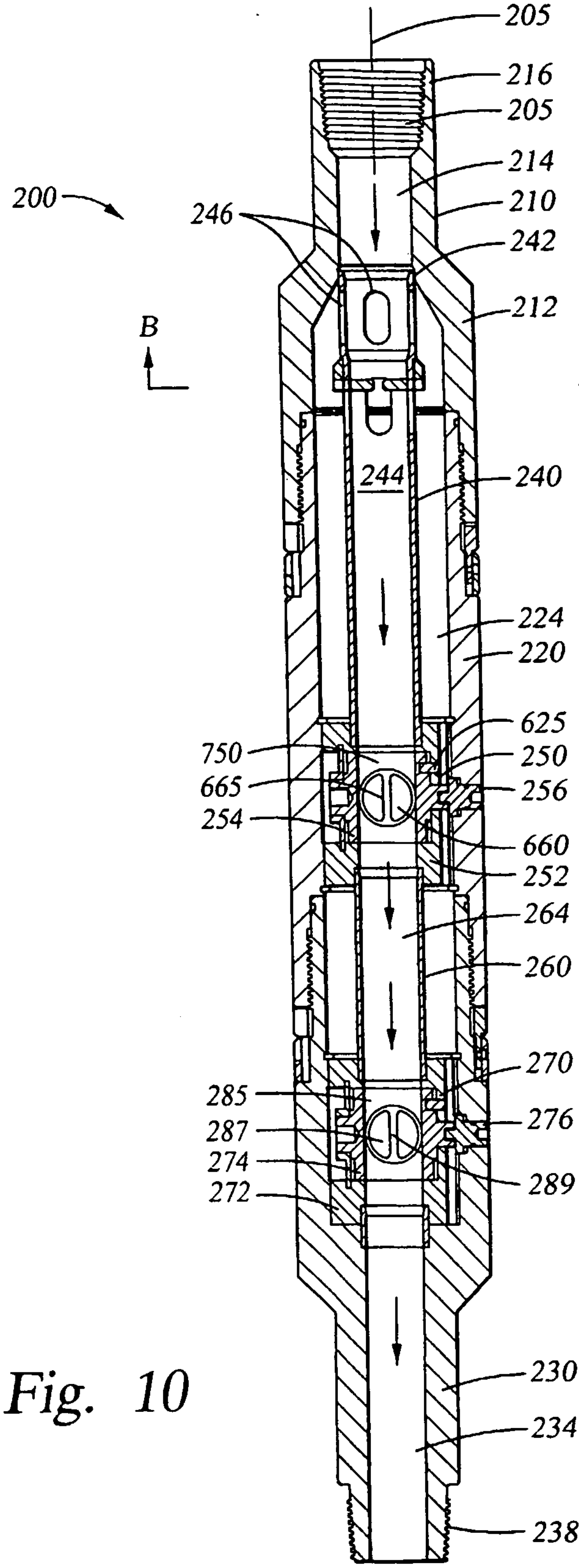

205
216
205
214
210
200
246
242
212
B
B
244
240
224
220
625
750
250
665
256
254
660
252
264
260
270
285
276
287
274
289
272
230
234
238

Fig. 10

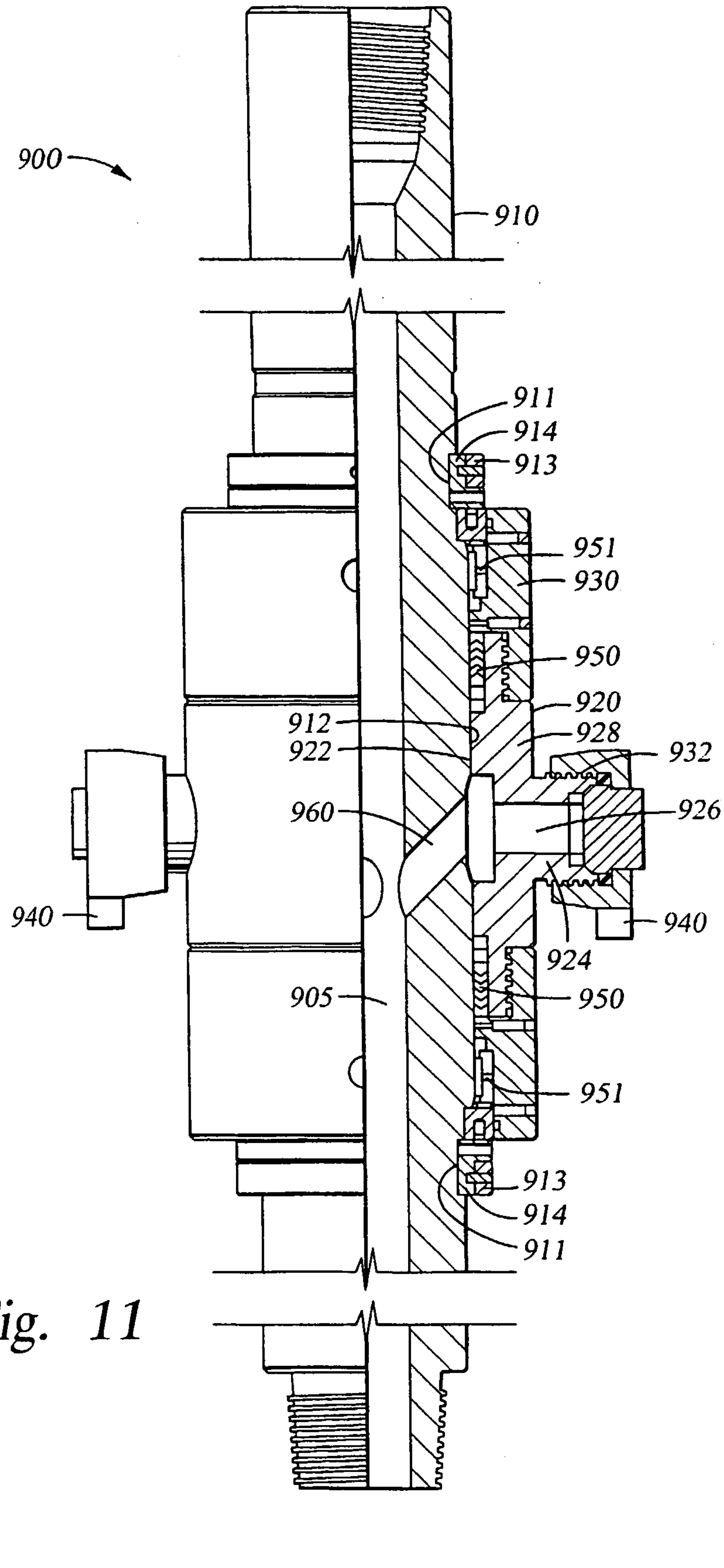

900
910
911
914
913
951
930
950
920
912
928
922
932
960
926
940
940
924
905
950
951
913
914
911

Fig. 11

APPARATUS AND METHOD AND SWIVEL FOR CEMENTING A STRING OF TUBULARS IN A BOREHOLE

The present invention relates generally to apparatus and methods and to a swivel for cementing downhole tubulars into a well bore.

A well-known method of drilling hydrocarbon wells involves disposing a drill bit at the end of a drill string and rotating the drill string from the surface utilising either a top drive unit or a rotary table set in the drilling rig floor. As drilling continues, progressively smaller diameter tubulars comprising casing and/or liner strings may be installed end-to-end to line the borehole wall. Thus, as the well is drilled deeper, each string is run through and secured to the lower end of the previous string to line the borehole wall. Then the string is cemented into place by flowing cement down the flowbore of the string and up the annulus formed by the string and the borehole wall.

To conduct the cementing operation, typically a cementing manifold is disposed between the top drive unit or rotary table and the drill string. Thus, due to its position in the drilling assembly, the cementing manifold must suspend the weight of the drill pipe, contain pressure, transmit torque, and allow unimpeded rotation of the drill string. When utilising a top drive unit, a separate inlet is preferably provided to connect the cement lines to the cementing manifold. This allows cement to be discharged through the cementing manifold into the drill string without flowing through the top drive unit.

In operation, the cementing manifold allows fluids, such as drilling mud or cement, to flow therethrough while simultaneously enclosing and protecting from flow a series of darts and/or spheres that are released on demand and in sequence to perform various operations downhole. Thus, as fluid flows through the cementing manifold, the darts and/or spheres are isolated from the fluid flow until they are ready for release.

Cementing manifolds are available in a variety of configurations, with the most common configuration comprising a single sphere/single dart manifold. The sphere is dropped at a predetermined time during drilling to form a temporary seal or closure of the flowbore of the drill string for example, or to actuate a downhole tool, such as a liner hanger, in advance of the cementing operation, for example. Once the cement has been pumped downhole, the dart is dropped to perform another operation, such as wiping cement from the inner wall of a string of downhole tubular members.

Another common cementing manifold comprises a single sphere/double dart configuration. The sphere may be released to actuate a downhole tool for example, followed by the first dart being launched immediately ahead of the cement, and the second dart being launched immediately following the cement. Thus, the dual darts surround the cement and prevent it from mixing with drilling fluid as the cement is pumped downhole through the drill string. Each dart typically also performs another operation upon reaching the bottom of the drill string, such as latching

into a larger dart to wipe cement from the string of downhole tubular members.

Many conventional cementing manifolds include external bypass lines such as the manifolds disclosed in US-A-5236035 and US-A-4854383, both hereby incorporated herein by reference for all purposes. In more detail, US-A-4854383 discloses a conventional external bypass cementing manifold for a single dart or double dart configuration. The single dart manifold comprises a tubular enclosure with a longitudinal passageway into which a dart is loaded. The dart holding/dropping mechanism is a ball valve connected via threads to the bottom of the tubular enclosure. An external bypass line with a bypass valve is connected via welds or threads to the tubular enclosure around the dart. For the double dart configuration, an identical arrangement of tubular enclosure, ball valve, and external bypass line with bypass valve is connected below the first tubular enclosure. Each of the darts in the dual dart configuration is separately releasable. In either case, when the dart is in the hold position, the ball valve remains closed to prevent flow through the tubular enclosure, and flow is routed around the dart through the bypass line by opening the bypass valve. To release the dart, the bypass valve is closed, and the ball valve is opened to allow flow through the tubular enclosure, thereby causing the dart to drop into the well string.

Conventional cementing manifolds often include other external connections, such as the side-mounted sphere dropping mechanisms disclosed in US-A-4854383 and US-A-5950724, hereby incorporated herein by reference for

all purposes. In more detail, US-A-4854383 discloses a ball dropping mechanism comprising a housing that mounts to the side of the lowermost tubular enclosure. The housing includes a bore in fluid communication with the longitudinal passageway through the tubular enclosure. In the hold position, a ball is positioned on a seat within the housing bore. To drop the ball, a screw shaft pushes the ball through the housing bore and into the longitudinal passageway, thereby dropping the ball down into the well string.

A number of disadvantages are associated with cementing manifolds having external connections, such as external bypass lines and side-mounted sphere dropping mechanisms. In particular, several large penetrations are required in the main body of the manifold (i.e. the tubular enclosures) for making the external connections. These penetrations create high stress concentration areas and hydraulically loaded areas that reduce the overall pressure-containing capacity of the cementing manifold. The manifold must also be capable of withstanding fatigue caused by changes in operating conditions, and stress concentration areas minimise the fatigue life of a cementing manifold. Further, the ball drop mechanism and external bypass connections protrude a considerable distance from the main body of the manifold, making these components more prone to damage during well operations. In addition, the external components connect via threads or welds to the main body of the manifold, thereby presenting a safety concern. In particular, the threads could back out or the welds could fail, which would expose rig personnel to high pressure, high velocity fluids. Thus, it would be advantageous to provide a cementing manifold with

internal bypass capability and with few external connections to the main body of the manifold. It would also be advantageous to eliminate threaded or welded connections to the main body of the manifold.

Some cementing manifolds have internal bypass capability, such as the TDH Top Drive Cementing Head offered by Weatherford/Nodeco. The TDH Head is purpose-built for use with a top-drive system and available in configurations to accommodate either a single ball/single dart, or single ball/dual darts. In both configurations, the TDH Head comprises a main body having a main bore and a parallel side bore, with both bores being machined integral to the main body. The darts are loaded into the main bore, and a dart releaser valve is provided below each dart to maintain it in the hold position. The dart releaser valves are side-mounted externally and extend through the main body. A port in the dart releaser valve provides fluid communication between the main bore and the side bore. The ball drop mechanism is externally side-mounted through one wall of the main body below the lowermost dart and extends into the main bore. The ball is retained by a collet, and to drop the ball, a screw shaft pushes the ball out into the main bore. When circulating prior to cementing, the darts are maintained in the main bore with the dart releaser valves closed. Fluid flows through the side bore and into the main bore below the lowermost dart via the fluid communication port in the dart releaser valve. To release a dart, the dart releaser valve is turned 90 degrees, thereby closing the side bore and opening the main bore through the dart releaser valve. Flow enters the main bore behind the dart, causing it to drop downhole.

Although the TDH Top Drive Cementing Head eliminates external bypass lines, it includes large penetrations in the main body for the dart releaser valves and ball drop device. These external components are also welded or threaded to the main body and protrude a significant distance. Thus, many of the concerns associated with external bypass manifolds have not been eliminated. Further, the parallel flow bores restrict the flow capacity of the TDH unit, which could present erosion problems, and also make it more difficult to remove leftover cement that could clog the bores. Thus, it would be advantageous to provide a cementing manifold with internal bypass capability that does not restrict the flow capacity of the manifold.

The Model LC-2 Plug Dropping Head offered by Baker Oil Tools, a Baker Hughes company, is an internal bypass cementing manifold for dropping either a dart or a sphere. The LC-2 comprises a mandrel with a releasable dart/sphere holding sleeve disposed therein, the sleeve being held in place by a rotatable lock pin. The sleeve includes ports that allow fluid bypass into an annular area while the sleeve is in the upper locked position. A pivoting stop extends across the bore of the mandrel below the sleeve to maintain the dart/sphere in the hold position. To drop the dart or sphere, the lock pin is turned 180 degrees to the drop position, which releases the sleeve. The sleeve moves downwardly in response to gravity and fluid flow until it reaches a stop shoulder. The downward movement of the sleeve releases the pivoting stop and restricts flow through the ports leading to the annular bypass area. Thus, the pivoting stop rotates out of the path of the dart

or sphere, and all fluid is directed longitudinally through the main bore of the sleeve behind the dart or sphere, causing it to drop down into the drill string.

Although the Model LC-2 Plug Dropping Head eliminates external bypass lines and other external components, the releasable sleeve presents disadvantages. Namely, if the sleeve gets hung up in the mandrel, flow will bypass the dart or sphere, thereby preventing its release. Further, because the lock pin provides only limited engagement with the sleeve, improper assembly or maintenance of the lock pin and sleeve connection could cause the sleeve to release prematurely. Thus, it would be advantageous to provide a cementing manifold with internal bypass capability that does not rely on a releasable sleeve as the dropping mechanism.

In addition to the disadvantages described above, conventional cementing manifolds are typically unitised and purpose-built such that they are not reconfigurable. For example, they cannot be converted from a single dart manifold to a double dart manifold and vice versa as the job requires. Further, after the manifold has been used for one job, new darts and/or spheres cannot be loaded at the rig site due to the high torques required to disconnect the components to allow reloading. Thus, traditional cementing manifolds must be redressed and reloaded in the shop after each use. In addition, some designs do not enable release of the darts or spheres while pumping fluid downhole due to fluid loads on the release mechanisms. Therefore, known cementing manifolds present various additional operating and maintenance disadvantages.

According to a first aspect of the present invention, there is provided apparatus for cementing a string of tubulars in a borehole, the apparatus comprising: an enclosure having a bore therethrough; a sphere canister having a sphere aperture therethrough; a sphere valve member having a hold position in which said sphere aperture is closed and a drop position in which said sphere aperture is open; and, a sphere disposed in said sphere aperture; said sphere valve member closing said sphere canister to flow in said hold position and opening said sphere canister to flow to release said sphere in said drop position.

According to a second aspect of the present invention, there is provided apparatus for cementing a string of downhole tubular members in a borehole, the apparatus comprising: an upper member; a first launching unit including a first dart canister and a first dart valve member disposed within a first modular member; a second launching unit including a second dart canister and a second dart valve member disposed with a second modular member; and, a third launching unit including a sphere canister and a sphere valve member disposed within a lower member.

According to a third aspect of the present invention, there is provided a method for dropping devices from an apparatus into a borehole, the method comprising: preloading a dart device and a sphere device within a bore of the apparatus; flowing fluid through the bore; isolating the dart device and the sphere device from the flowing fluid when the apparatus is in a holding position; dropping the sphere device into the borehole while the fluid is

flowing through the bore; and, dropping the dart device into the borehole while the fluid is flowing through the bore.

According to a fourth aspect of the present invention, there is provided an assembly for cementing a string of tubulars in a borehole, the assembly comprising: a swivel; and, a cementing manifold with internal bypass means.

According to a fifth aspect of the present invention, there is provided a swivel for cementing a string of tubulars in a borehole, the swivel comprising: an outer stationary member with cement connections; and, an inner rotating member with a bore therethrough; wherein said outer stationary member is formed from one piece.

In one aspect, the preferred embodiment of the present invention provides a cementing manifold having a number of advantages over conventional cementing manifolds. In particular, the preferred embodiment of the cementing manifolds of the present invention have: modular housings that can be stacked together and interconnected to add multi-dart or multi-sphere capability; substantially identical, interchangeable valves; internal bypass capability; a minimum number and minimum size of penetrations into the pressure containing components; and no externally mounted, welded or threaded components.

In another aspect, the preferred embodiment of the present invention provides a cementing swivel providing a number of advantages over conventional swivels. In particular, the preferred embodiment of the swivel of the present invention has cement connections and tie-off

connections that are formed integrally into the housing, redundant cement connections, angled cement ports to minimise erosion, and seal assemblies that do not require individual placement of each seal between the mandrel and the housing of the swivel.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 schematically depicts an exemplary drilling system in which various embodiments of the present invention may be utilised;

Figure 2 is a cross-sectional side view of an example of a preferred embodiment of a single dart/single sphere cementing manifold of the present invention, with both valves in the closed position;

Figure 3 is a cross-sectional side view of an example of a preferred embodiment of a double dart/single sphere cementing manifold of the present invention, with all valves in the closed position;

Figure 4 is a cross-sectional side view of an example of a preferred embodiment of a single large sphere cementing manifold of the present invention, with the valve in the closed position;

Figure 5 is a cross-sectional bottom view through section B-B of Figure 2, with Figure 5A being an enlargement of a detail of Figure 5;

Figure 6 is an enlarged view of a valve of the cementing manifold of Figure 2;

Figure 7 is a cross-sectional top view of the valve of Figure 6, taken along section A-A;

Figure 8 is an end view of a valve stem of Figure 6;

Figure 9 is a cross-sectional side view of the single dart/single sphere cementing manifold of Figure 2 after the sphere has been dropped, with the first valve closed and the second valve open;

Figure 10 is a cross-sectional side view of the single dart/single sphere cementing manifold of Figure 2 after both the sphere and the dart have been dropped, with both valves open; and,

Figure 11 is a side view, partially in cross-section, of an example of a preferred embodiment of a cementing swivel of the present invention.

Figure 1 schematically depicts an exemplary drilling system in which the present invention may be utilised. However, one of ordinary skill in the art will understand that the preferred embodiments are not limited to use with a particular type of drilling system. The drilling rig 100 includes a derrick 102 with a rig floor 104 at its lower end having an opening 106 through which drill string 108 extends downwardly into a well bore 110. The drill string 108 is driven rotatably by a top drive drilling unit 120 that is suspended from the derrick 102 by a travelling

block 122. The travelling block 122 is supported and movable upwardly and downwardly by a cabling 124 connected at its upper end to a crown block 126 and actuated by conventional powered draw works 128. Connected below the top drive unit 120 is a kelly valve 130, a pup joint 132, a cementing swivel 900, and a cementing manifold, such as a single dart/single sphere cementing manifold 200 according to an embodiment of the present invention. A flag sub 150, which provides a visual indication when a dart or sphere passes therethrough, is connected below the cementing manifold 200 and above the drill string 108. A drilling fluid line 134 routes drilling fluid to the top drive unit 120, and a cement line 136 routes cement through a valve 138 to the swivel 900.

Any cementing swivel may be utilised, but preferably the cementing swivel 900 is configured as shown in Figure 11. Referring now to Figures 1 and 11, the swivel 900 includes a mandrel 910, a housing 920, and a cap 930, with upper and lower seal assemblies 950 disposed above and below a cement port 960 and between the mandrel 910 and the housing 920. The swivel 900 preferably provides cement line connections 940 and tie-off connections 942,944 (shown in Figure 1) that are integral to the housing 920, thereby avoiding the disadvantages of conventional swivel connections that are typically threaded, welded, or bolted on. The threaded and bolted connections can come loose over time, and the welded connections are subject to damage or failure due to corrosion at the weldment. Conventional swivel connections are further subject to fatigue caused by the weight of the overhanging cement line 136 and cement valve 138 that connect thereto. Mandrel 910 includes upper and lower threaded connections for connecting the upper end

of mandrel 910 to top drive unit 120 and the lower end to the cementing manifold 200 connected to the upper end of drill string 108.

The housing 920 includes one or more radially projecting integral conduits 924 with a cement port 926 extending through conduit 924 and the wall 928 of housing 920. Housing 920 and conduits 924 are preferably made from a common tubular member such that conduits 924 are integral with housing 920 and do not require any type of fastener including welding. Conduit 924 provides a connection means, such as threads 932, for connecting cement line 136 to swivel 900.

The preferred swivel 900 also includes two swivel connections 940 for redundancy in case one connection 940 becomes damaged. The cement ports 960 within the mandrel 910 are preferably angled so that as cement flows through the connection 940, it enters the throughbore 905 of the mandrel 910 generally in the downwardly direction. This allows the cement to impinge on the wall of throughbore 905 at an angle and minimises erosion of the ports 960 and mandrel 910.

An additional feature of the preferred swivel 900 is that the mandrel 910 includes a common cylindrical outer surface 912 in the areas of the bearings 951 and seal assemblies 950, which are disposed in recessed areas in the housing 920. Conventional mandrels included a step shoulder on the mandrel for the seals, requiring individual seal placement. The common cylindrical outer surface 912 of the mandrel 910 allows for the bearings 951 and seal assemblies 950 to be positioned within the housing 920 as

one unit, such that the mandrel 910 can then slide through the bore 922 of the housing 920 and assembled cap 930. A groove 911 is provided at each end of the mandrel 910, and an externally threaded, split cylindrical ring 914 is positioned within the grooves 911. An internally threaded ring 913 is screwed onto the split ring 914, and these rings 913,914 hold the assembled housing 920 and cap 930 in place on the mandrel 910.

Referring again to Figure 1, in operation, drilling fluid flows through line 134 down into the drill string 108 while the top drive unit 120 rotates the drill string 108. The housing 920 of cementing swivel 900 is tied-off to the derrick 102 via lines or bars 140,142 such that the swivel housing 920 cannot rotate and remains stationary while the mandrel 910 of the swivel 900 rotates within housing 920 to enable the top drive unit 120 to rotate the drill string 108.

To perform an operation such as, for example, actuating a downhole tool to suspend a tubular 144, such as a casing string or liner, from existing and previously cemented casing 146, a sphere may be dropped from the cementing manifold 200. Then, once the tubular 144 is suspended from the casing 146 via a rotatable liner hanger 151, cement is pumped down through the drill string 108 and through the tubular 144 to fill the annular area 148 in the uncased well bore 110 around the tubular 144. To start the cementing operation, the kelly valve 130 is closed, and the valve 138 to the cement line 136 is opened, thereby allowing cement to flow through the swivel 900 and down into the drill string 108. Thus, the swivel 900 enables

cement flow to the drill string 108 while bypassing the top drive unit 120.

It is preferable to rotate the drill string 108 during cementing to ensure that cement is distributed evenly around the tubular 144 downhole. More specifically, because the cement is a thick slurry, it tends to follow the path of least resistance. Therefore, if the tubular 144 is not centred in the well bore 110, the annular area 148 will not be symmetrical, and cement may not completely surround the tubular 144. Thus, it is preferable for the top drive unit 120 to continue rotating the drill string 108 through the swivel 900 while cement is introduced from the cement line 136. When the appropriate volume of cement has been pumped into the drill string 108, a dart is typically dropped from the cementing manifold 200 to latch into a larger dart 152 to wipe cement from the tubular 144 and land in the landing collar 153 adjacent the bottom end of the tubular 144.

Although Figure 1 depicts one example drilling environment in which the preferred embodiments of the present invention may be utilised, one of ordinary skill in the art will readily appreciate that the preferred embodiments of the present invention may be utilised in other drilling environments such as, for example, to cement casing into an offshore wellbore.

Referring now to Figures 2 to 4, the preferred embodiments of the cementing manifold of the present invention may be provided in a variety of different configurations including a single dart/single sphere manifold 200 as shown in Figure 2, a double dart/single

sphere manifold 300 as shown in Figure 3, or a single large sphere manifold 400 as shown in Figure 4.

Referring now to Figure 2, the single dart/single sphere manifold 200 comprises an upper cap 210, a housing 220, and a lower cap 230. The upper cap 210 comprises a body 212 having a longitudinal throughbore 214, a box connection end 216 for attachment to another tool, such as the swivel 900 shown in Figure 11, and a lower threaded box end 218 which is castellated forming preferably six circumferentially disposed slots 219 for aligning with the upper end of housing 220. The housing 220 comprises a body 222 having a longitudinal throughbore 224, an upper threaded pin end 226 which is also castellated forming preferably six circumferentially disposed slots 227 for aligning with the lower castellated end of upper cap 210, and a lower threaded box end 228 which is castellated having preferably six circumferentially disposed slots 229 for aligning with the upper castellated end of lower cap 230. The lower cap 230 comprises a body 232 having a longitudinal throughbore 234, an upper threaded pin end 236 which is castellated having preferably six circumferentially disposed slots 237 for aligning with the lower castellated end of housing 220, and a lower pin connection end 238 for attachment to another tool, such as a flag sub 150, or directly to the drill string 108.

The upper cap 210, housing 220, and lower cap 230 form an enclosure that is load-bearing and pressure-containing. The box end of upper cap 210 connects to the pin end of housing 220 preferably via threads 215, and high pressure seals 211 are provided therebetween. The high pressure seals 211 are provided for pressure and fluid containment.

The respective slots 219,227 in the upper cap 210 and housing 220 are also aligned, then dogs 280 are installed in every other set of aligned slots 219,227, and a cap screw 282 fixes each dog 280 into place. A circumferential ring 284 maintains all dogs 280 in place circumferentially.

Similarly, the box end of housing 220 and the pin end of lower cap 230 connect via threads at 225 with high pressure seals 221 provided therebetween, and dogs 280 are preferably positioned in every other set of aligned slots 229,237 of the housing 220 and lower cap 230, respectively. Each dog 280 is held in place via a cap screw 282, and a circumferential ring 284 maintains all dogs 280 in position.

Disposed within the throughbores 214,224 of the upper cap 210 and housing 220 is a dart canister 240 having a cylindrical body 242 with a throughbore 244 into which a dart 290 is loaded. The cylindrical body 242 includes flow slots 246 circumferentially disposed around the upper end, an equalising port 247 adjacent the lower end, and a seal 248 at the lowermost end. The flow slots 246 provide a fluid path from the throughbore 214 of the upper cap 210 to the annular area 249 in the housing throughbore 224 around the dart canister 240. The equalising port 247 enables pressure equalisation when the fins 292 of the dart 290 form a seal with canister 240 that traps pressure in the canister 240.

At the upper end of the dart canister 240, a retention mechanism 500 prevents the dart 290 from floating upwardly out of the upper end of canister 240. Figure 5 depicts a cross-sectional bottom view of the retention mechanism 500

taken at section B-B of Figure 2, and Figure 5A depicts an enlarged view of the connection details. The retention mechanism 500 comprises two fingers 510, each finger 510 extending approximately halfway across the diameter of the throughbore 244 of the dart canister 240. The fingers 510 are connected such that they are only capable of a hinged movement downwardly into the canister 240, and the fingers 510 are biased to the position shown in Figure 2 and Figure 5 by a torsional spring 520. The fingers 510 connect to the dart canister 240 by a clevis pin 530 that extends through the body 242 of the dart canister 240, through the end of the finger 510, and through the torsional spring 520. A cotter pin 540 is provided at the end of the clevis pin 530 to prevent the clevis pin 530 from backing out.

Referring again to Figure 2, a first valve 250 is positioned within the housing 220 and below the dart canister 240 to act as a dart holding/dropping mechanism. The first valve 250 comprises a body 252, a rotatable plug 254, and an actuating stem 256 to enable manual or remote actuation of the plug 254 within the body 252 of valve 250. Retainer rings 251,253 are disposed in shoulders of the housing 220 above and below the body 252 to properly position the valve 250 in the housing 220.

Below the first valve 250, and disposed within the housing 220 and the lower cap 230, is a sphere canister 260, which has a cylindrical body 262 with a throughbore 264. A sphere 295 fits within the throughbore 264, and the cylindrical body 262 includes an equalising port 266 adjacent the lower end, and a seal 268 at the lowermost end. The equalising port 266 enables pressure equalisation should the sphere 295 form a seal with canister 260 that

traps pressure in the canister 260. A second valve 270 is positioned within the lower cap 230 and below the sphere canister 260 to act as a sphere holding/dropping mechanism. The second valve 270 is preferably identical to the first valve 250 so as to be interchangeable and comprises a body 272, a rotatable plug 274, and an actuating stem 276 for manual or remote actuation of plug 274 within body 272 of the valve 270. A retainer ring 271 is disposed in a shoulder of the lower cap 230 above the valve body 272 to properly position the second valve 270 in the lower cap 230. A sleeve 297 is provided as a spacer to fit between the counterbore in the body 272 of the valve 270 and the lower cap 230, which enables adjustable spacing and interchangeable parts.

Figures 6 to 8 depict enlarged views of the components of the first valve 250 in more detail. Preferably the second valve 270 is identical to the first valve 250 in construction and operation so that the valves 250,270 are interchangeable. Thus, only the first valve 250 is described in detail. Figure 6 provides an enlarged view of the first valve 250 within the manifold of Figure 2, Figure 7 provides a cross-sectional top view of the same valve 250 taken along section A-A of Figure 6, and Figure 8 provides an end view of the valve stem 256. Valve 250 includes an upper milled slot 610 along the length of the body 252 to enable installation of the valve 250 into the housing 220. Slots 612,614 are also milled into the lower portion of the body 252 to accept a plug retainer plate 620, which is a split plate disposed above and below the plug 254 to position the plug 254 with respect to the body 252. The retainer plate 620 is designed to encircle a boss 630 on one side of the plug 254 that enables rotation between the

valve body 252 and valve plug 254. O-rings 712,714 are provided between the valve body 252 and plug 254 primarily to protect the valve 250 from contamination caused by debris rather than to provide pressure containment.

The plug 254 includes a throughbore 750 with a first end 752 and a second end 754, a transverse bore 660 having an open port 652 with a fouling bar 665 disposed across the diameter of the open port 652, and a closed side 650 opposite transverse bore 660. The transverse bore 660 extends perpendicularly to the throughbore 750 and communicates therewith. The fouling bar 665 is provided to prevent the sphere 295 from floating into the valve 750 and interfering with its operation. Although the plug 254 is depicted as being cylindrical in shape, one of ordinary skill in the art will appreciate that the plug 254 may be provided in a variety of shapes such as, for example, a spherical shape.

A pin 625 is provided between the valve body 252 and the valve plug 254. The pin 625 enables proper alignment of the valve plug 254 within the body 252 so that the valve 250 is installed in the closed or hold position as shown in Figure 2 and in Figure 7. The pin 625 is shown in top view in Figure 8 disposed in a travel slot 810 that only allows a 90° rotation of the valve 250 from the closed, dart-holding position to the open, dart-dropping position. Thus, the pin 625 aligns the valve 250 properly to be installed in the closed position and also allows the valve 250 to travel only 90° between the hold and the drop positions.

Referring to Figure 7, the stem 256 is installed in an aperture in the wall of housing 220 and includes a high-pressure seal 716 engaging housing 220 for pressure and fluid containment, and a flange 720 that prevents the stem 256 from being forced out of the aperture of housing 220 by fluid pressure. Thrust bearings 725 between the flange 720 and housing 220 offset the frictional load exerted on the interior face 727 of the flange caused by fluid pressure inside of the valve 250. Thus, the bearings 725 eliminate the pressure-induced frictional load, thereby allowing the stem 256 to rotate.

Referring to Figure 6, any voids in the cementing manifold 200, such as the void 640 below the retainer plate 620 in the body 252 of the valve 250 and the gap 645 between the plug 254 and the milled slot 610 in the valve body 252 can potentially become filled with cement or other debris. If the cement hardens in such voids and gaps, then the manifold 200 will require excessive torque to actuate and will not otherwise operate properly. Thus, in the preferred embodiments of the present invention, all voids, such as void 640, and all gaps, such as gap 645, are filled with a solid metal part or a flexible filler material, such as urethane, or a silicone or a rubber boot, so that cement and other debris cannot enter the area and harden.

Referring to Figure 6 and Figure 7, to assemble the valve 250 into the housing 220, the retainer ring 251 is installed. Then the stem 256, with the high pressure seal 716 and thrust bearings 725, is installed from inside the housing 220, thereby ensuring that the stem 256 can never be removed or loosened inadvertently. Due to the milled slot 610 along the length of the valve 250, the valve body

252 and plug 254 can be assembled into the housing 220 as shown in Figure 7, oriented such that the protruding key 730 of the stem 256 fits into the protruding slot portion 710 of the plug 254, which ensures that the valve 250 is installed in the closed position.

Referring now to Figure 2, the single dart/single sphere cementing manifold 200 is depicted in the holding position before the sphere 295 or the dart 290 are dropped, with both the first valve 250 and the second valve 270 in the closed position. To load the dart 290 and sphere 295 into the cementing manifold 200 as shown in Figure 2, the first valve 250 is opened and the second valve 270 is closed. The sphere 295 is rolled into the manifold 200 through the upper cap 210, through the dart canister 240, through the first valve 250, and into the sphere canister 260 until the sphere 295 engages the closed second valve 270. Then the first valve 250 is closed, and a dart 290 is installed into the throughbore 214 of the upper cap 210. The fins 292 of the dart 290 engage the body 242 and collapse within the dart canister 240 such that the dart 290 must be pushed down into the throughbore 244 of the dart canister 240 until the bottom of the dart 290 engages the closed side 650 of first valve 290.

Preferably, once the sphere 295 and dart 290 have been dropped from the manifold 200, the manifold 200 can then be reloaded in the field. However, in larger sizes, the dart 290 may be too large to be forced into the throughbore 244 of the dart canister 240 without mechanical assistance. Therefore, in an alternative embodiment, the dart canister 240 is provided as a two-piece component having upper and lower portions such that the upper portion of the dart

canister 240 is removable to enable loading of larger-sized darts 290. Thus, the cementing manifold 200 is preferably designed to allow for reloading in the field so that the manifold 200 may be moved from rig to rig and only returned to the shop when necessary for redressing and workover rather than after each job for reloading.

As previously described, the upper cap 210 is threadingly connected at 215 to the housing 220, and the housing 220 is threadingly connected at 225 to the lower cap 230. During operation, the top drive unit 120 exerts high torque on the cementing manifold 200, which tends to tighten up the threaded connections 215,225. Then, to reload the cementing manifold 200 after the sphere 295 and dart 290 have been dropped, the upper cap 210, the housing 220, and the lower cap 230 must be broken out from one another at the threads 215,225, which would typically require high torques, such as those exerted by the top drive unit 120.

To enable isolation of the threaded connections 215,225 without fully preloading the connections 215,225 with make-up torque, the slots 219 of the castellated box end 218 of upper cap 210 are matched up with the slots 227 of the castellated pin end 226 of the housing 220. Similarly, the slots 219 of the castellated box end 228 of housing 220 are matched up with the slots 237 of castellated pin end 236 in the lower cap 230. For purposes of preventing tightening at the threads 215,225, only three sets of mating slots disposed 120 degrees apart is preferred, but three additional sets of mating slots are preferably provided circumferentially on each of the upper cap 210, housing 220 and lower cap 230 to enable alignment

of the valve stems 256,276 that extend through the housing 220 and lower cap 230, respectively, to within 30 degrees. It is preferred, but not required, that the valve stems 256,276 extend from the same side of the manifold 200 for ease of manual actuation.

In more detail, when the housing 220 and the lower cap 230 are threaded together at 225, for example, the mating slots 229,237 on the housing 220 and the lower cap 230, respectively, may be misaligned. In that circumstance, the threaded connection 225 is backed off enough to align the slots 229,237 so that dogs 280 can be installed in every other set of the slots 229,237. Although the slots 229,237 may be aligned, however, it is also preferred that the valve stems 256,276 extend from the same side of the cementing manifold 200. Therefore, the threads 225 may need to be backed off 180° to achieve the preferred position of the two valve stems 256,276. Positioning the valve stems 256,276 is especially preferred when the valves 250,270 are physically opened and closed by manual operation. Thus, with the valve stems 256,276 on the same side of the manifold 200, an operator that goes up on a line to open the valves 250,270 in the proper sequence can easily identify which is the second valve 270 and which is the first valve 250.

Once proper alignment has been achieved, dogs 280, which are capable of withstanding the rated torque of the top-drive unit 120, are installed into the aligned sets of slots to isolate the threaded connections 215,225. The dogs 280 are installed and held in place by a circumferential ring 284 that fits over all of the dogs 280. The ring 284 includes equally spaced apertures (not

shown) that equal the number of dogs 280 to be installed, such that the dogs 280 may be installed one at a time. The ring 284 fits over all of the mated slots between two components, such as slots 229,237 between the housing 220 and the lower cap 230. The apertures through the ring 284 are positioned to allow for a dog 280 to be installed into preferably every other set of slots 229,237. Then a cap screw 282 is threaded through each dog 280 to hold the dogs 280 in position. Once all the dogs 280 have been installed, the ring 284 is rotated to dispose the apertures over empty sets of slots 229,237. In this position, the ring 284 will prevent the loaded dogs 280 from backing out, even if the cap screws 282 come loose. The dogs 280 and ring 284 are designed to be flush with the exterior surface of the manifold 200. An identical procedure is followed to install dogs 280 into mated slots 219,227 between the upper cap 210 and the housing 220 utilising another circumferential ring 284.

To describe the flow path through the cementing manifold 200, reference will now be made to Figure 2. Figure 6, and Figure 7. Figure 2 provides a cross-sectional view of the cementing manifold 200 in the holding position, with first and second valves 250,270 closed. Referring to Figure 6, which depicts an enlarged view of the first valve 250 in the position shown in Figure 2, the closed side 650 of the valve plug 254 is positioned against the dart canister 240, the throughbore 750 is disposed perpendicular to the longitudinal axis 205 of the manifold 200, and the transverse bore 660 is facing downwardly in fluid communication with the throughbore 264 of the sphere canister 260. The fouling mechanism 665 is positioned in the transverse bore 660 so as to prevent the sphere 295

from floating upwardly to inhibit the operation of the first valve 250. The design of the valve plug 254 ensures that no hydraulically induced loads are exerted on the valve body 252 when the valve 250 is in the closed position.

Figure 7 depicts the first valve 650 in cross-section through section A-A of Figure 6. In this cross-section, the full throughbore 750 and the fowling mechanism 665 of the valve 250 is more clearly depicted. The body 252 of the valve 250 includes a D-shape cut-out section 760 that can not be seen in Figure 2. The D-shape cut-out section 760 enables fluid flow through annular area 249 past the plug 254 of the valve 250 through the valve body 252 when the valve 250 is in the closed position. Although the cut-out section 760 is depicted as being D-shape in Figure 7, one of ordinary skill in the art will readily appreciate that the section 760 could be any other shape that would allow fluid to bypass the plug 254.

With the cementing manifold 200 in the holding position as shown in Figure 2, the fluid flows along the path represented by the flow arrows. Namely, the drilling fluid first flows into the throughbore 214 of the upper cap 210, then out through the flow slots 246 in the dart canister 240, and down through the annular area 249 between the dart canister 240 and housing 220 in the housing throughbore 224. Because both valves 250,270 are closed, there is no flow path through the plug 254 of the first valve 250, so the flow will bypass the plug 254 through the D-shape section 760 in the valve body 252. The flow will continue into the annular area 249 between the sphere holder 260 and the lower cap 230. Again, because the

second valve 270 is closed, there is no straight flow path through the plug 274 of the second valve 270, so flow will move through the body 272 via the D-shape section. However, because there is an open flow path below the lower cap 230, the fluid will flow into the throughbore 285 of the second valve 270, through the transverse bore 287 of the second valve 270, and downwardly into the drill string 108.

When a valve 250,270 is turned, the flow path through the manifold 200 changes. Referring to Figure 9, the second valve 270 has been actuated by rotating the valve plug 274 by 90 degrees with respect to the valve body 272, thereby opening the valve 270 and dropping the sphere 295. In the rotated position, the transverse bore 287 of the valve 270 is disposed perpendicular to the longitudinal axis 205 of the manifold 200, and the fouling mechanism 289 is no longer in the flow path. The throughbore 285 in the second valve plug 274 is aligned with the longitudinal axis 205 of the manifold 200, thereby becoming open and providing an opening for the sphere 295 to drop down into the throughbore 234 of the lower cap 230.

Thus, as shown in Figure 9, once the sphere 295 has dropped, the second valve 270 will be in the dropping position with an open throughbore 285 aligned with the throughbores 264,234 of the sphere canister 260 and the lower cap 230, respectively, and the first valve 250 will remain in the holding position. In this configuration, as referenced by the flow arrows, the drilling fluid flows into the throughbore 214 of the upper cap 210, through the flow slots 246 of the dart canister 240, into the annular area 249 between the dart canister 240 and the housing 220,

and into the D-shape section 760 of the first valve 250. Because there is an open flow path below the first valve 250, the fluid then flows into the throughbore 750 through end 752 of valve plug 252 and downwardly through the transverse bore 660, the sphere canister 260, the throughbore 285 of the second valve 270, and downwardly into the drill string 108.

Referring to Figure 10, after the cement has been pumped through the manifold 200 in the position shown in Figure 9, the valve plug 254 of the first valve 250 is rotated by 90 degrees with respect to the valve body 252 to open valve 250 and drop the dart 290. In the rotated position, the transverse bore 660 is disposed perpendicular to the longitudinal axis 205 of the manifold 200 and the fouling mechanism 665 is no longer in the flow path. The throughbore 750 in the first valve plug 254 is aligned with the longitudinal axis 205 of the manifold 200, thereby providing an opening for the dart 290 to drop down into the throughbore 264 of the sphere canister 260, through the second valve 270 and lower cap 230, and down into the drill string 108. Thus, when the first valve 250 is rotated to drop the dart 290, the throughbore 750 of the valve plug 254 is aligned to allow flow straight through the cementing manifold 200 and down into the drill string 108. This position of the cementing manifold 200 is called the dropping position.

The single dart/single sphere manifold 200 shown in Figure 2 is reconfigurable to accommodate multi-darts or multi-spheres, such as, for example, the dual dart/single sphere manifold 300 as shown in Figure 3. In many respects, the manifold 300 includes the same components as

the manifold 200 of Figure 2, but also includes an additional housing 320, an additional dart holder 340, and an additional dropping/holding valve 350 comprising a valve body 352, a valve plug 354, and a valve stem 356. Thus, the housing 220 of the single dart/single sphere cementing manifold 200 is preferably modular in design to enable additional housings, such as housing 320, to be stacked together and interconnected between the upper cap 210 and the lower cap 230. Further, all of the valves 250,270,350 are preferably identical and interchangeable. This enables the operator to stack as many dart or sphere combinations as desired.

In contrast, the multi-dart or multi-sphere cementing manifolds of the prior art were either purpose-built or required the interconnection of single manifolds stacked together, creating a very long cementing manifold. In the multi-dart manifold 300 shown in Figure 3, rather than adding approximately 8 feet (approx. 2.4m) by connecting two single dart manifolds together, only the length of the additional housing 320 is added, which is approximately 3 1/2 feet (approx. 1m) long.

When only a single dart 290 is dropped from the manifold 200 of Figure 2, some of the cement at the leading end mixes with the previously pumped drilling fluid to form a contaminated mixed fluid termed "rotten cement". Thus, as previously described, the dual dart manifold 300 may be desired to prevent the cement from mixing with drilling fluid downhole, especially if only a small quantity of cement will be pumped. Thus, after the sphere 295 is dropped from the manifold 300 of Figure 3, the first dart 390 is dropped immediately before the cement is flowed

downhole, and the second dart 290 is dropped immediately following the flow of cement downhole to provide containment and prevent the cement from mixing with drilling fluid downhole.

Figure 4 depicts a modified cementing manifold 400 containing only a large elastomeric sphere 495. The cementing manifold 400 comprises the upper cap 210, lower cap 230, and a single valve 270 that acts as the sphere holding/dropping mechanism, which are the same components used in the manifolds 200,300 of Figures 2 and 3, respectively. However, a specially designed larger sphere canister 460 is disposed above the valve 270 within the upper cap 210 and lower cap 230. Canister 460 includes an upper enlarged bore 462 and a lower reduced diameter bore 464 forming a conical transition 466 therebetween. The enlarged sphere 495 is received within enlarged bore 462 and then by means of transition 466 is forced into reduced diameter bore 464 for launching downhole. The elastomeric material of sphere 495 allows sphere 495 to compress to fit within reduced diameter bore 464.

Thus, the preferred cementing manifolds 200,300,400 of the present invention provide a number of advantages. In particular, the preferred manifolds 200,300,400 are easily assembled and disassembled, providing reloading capability in the field. The preferred manifolds 200,300,400 include dogs 280 that allow high torque transmission without requiring pre-torque at the threaded connections. Additionally, the preferred manifolds 200,300,400 include modular housings 220,320 that can be stacked together and interconnected to add multi-dart or multi-sphere capability, as desired, thereby providing a high degree of

flexibility. Further, the preferred manifolds 200,300,400 include identical, interchangeable valves 250,270,350 that require only a 90° turn to open or close. The preferred valves 250,270,350 are pressure balanced to minimise resistance to rotation, thereby enabling release of the darts 290,390 and spheres 295,495 while flowing. The preferred valves 250,270,350 also include large throughbores 750,285,385 to minimise flow erosion. Additionally, the preferred manifolds 200,300,400 provide internal bypass capability, internally loaded darts 290,390 and spheres 295,495, and valve bodies 252,272,352 that install internally. Thus, only the small diameter valve stems 256,276,356 protrude externally from the pressure containing housings 220,320 and lower cap 230, thereby minimising penetrations that act as stress concentration areas. Further, there are no externally mounted components that are welded or threaded.

Embodiments of the present invention have been described with particular reference to the examples illustrated. However, it will be appreciated that variations and modifications may be made to the examples described within the scope of the present invention.

CLAIMS

1. Apparatus for cementing a string of tubulars in a borehole, the apparatus comprising:

an enclosure having a bore therethrough;

a sphere canister having a sphere aperture therethrough;

a sphere valve member having a hold position in which said sphere aperture is closed and a drop position in which said sphere aperture is open; and,

a sphere disposed in said sphere aperture;

said sphere valve member closing said sphere canister to flow in said hold position and opening said sphere canister to flow to release said sphere in said drop position.

2. Apparatus according to claim 1, further comprising:

a dart canister having a dart aperture therethrough;

a dart valve member having a hold position in which said dart aperture is closed and a drop position in which said dart aperture is open; and,

a dart disposed in said dart aperture;

said dart valve member closing said dart canister to flow in said hold position and opening said dart canister to flow to release said dart in said drop position.

3. Apparatus according to claim 2, wherein said dart canister includes a retention member.

4. Apparatus according to claim 2 or claim 3, wherein said valve members are movable from said hold to said drop positions when fluid is flowing through said bore.

5. Apparatus according to any of claims 2 to 4, wherein said valve members are substantially identical.

6. Apparatus according to any of claims 2 to 5, wherein said canisters include equalising ports.

7. Apparatus according to any of claims 2 to 6, wherein said dart canister includes flow slots.

8. Apparatus according to any of claims 2 to 7, comprising flow by-passes around said sphere and dart valve members through said bore.

9. Apparatus according to claim 8, wherein, when said sphere and dart valve members are in the hold position, a flow path is formed that extends through said bore and said flow by-passes.

10. Apparatus according to claim 8 or claim 9, wherein, when said dart valve member is in said hold position and said sphere valve member is in said drop position, a flow path is formed that extends through said bore, through said by-pass around said dart valve member, and through said sphere valve member.

11. Apparatus according to any of claims 8 to 10, wherein, when said dart and sphere valve members are in the drop position, a flow path is formed that extends through said bore and through said dart and sphere valve members.

12. Apparatus according to any of claims 2 to 11, wherein said enclosure includes:

a first member having said bore passing therethrough for fluid flow;

a second member having said bore passing therethrough for fluid flow; and,

a modular body connecting said first and second members, said modular body having said bore passing therethrough;

said dart canister and dart valve member being mounted within said modular body; and,

said sphere canister and sphere valve member being mounted within said second member.

13. Apparatus according to claim 12, comprising a spacer member.

14. Apparatus according to claim 12 or claim 13, wherein said first member forms a connection with said modular body and said modular body forms a connection with said second member.

15. Apparatus according to claim 14, wherein said connections comprise dogs disposed within aligned slots.

16. Apparatus according to claim 15, wherein said dogs are retained by a ring.

17. Apparatus according to any of claims 1 to 16, wherein said sphere valve member further comprises:

a valve body disposable within said bore; and,

a plug having a hold position and a drop position.

18. Apparatus according to claim 17, wherein said plug includes a pass-through passage and a transverse passage, said pass-through passage extending through said plug and said transverse passage extending transversely from said pass-through passage through a side of said plug.

19. Apparatus according to claim 18, wherein said pass-through passage and said transverse passage form a D-shape aperture in said plug.

20. Apparatus according to claim 18 or claim 19, further including a fouling member extending into said transverse passage.

21. Apparatus according to any of claims 17 to 20, wherein said valve body includes an alignment surface for aligning said valve body within said enclosure.

22. Apparatus according to any of claims 17 to 21, further including retaining plates for retaining said valve body within said enclosure.

23. Apparatus according to any of claims 17 to 22, wherein said plug includes rotation bosses on opposing sides thereof, said bosses being received in opposing bores in said valve body for the rotation of said plug within said valve body.

24. Apparatus according to any of claims 17 to 23, further comprising a pin disposed between said valve body and said plug.

25. Apparatus according to any of claims 17 to 24, further including filler material disposed in recesses around said sphere valve member to prevent the accumulation of debris therein.

26. Apparatus according to any of claims 17 to 25, wherein said valve body includes a by-pass port therethrough that allows fluid flow around said sphere valve member whether said sphere valve member is in said hold or drop positions.

27. Apparatus according to any of claims 17 to 26, further including an actuation stem extending through a wall of said enclosure and engaging said plug to actuate said plug between said hold and drop positions.

28. Apparatus according to claim 27, wherein said actuation stem further comprises a flange that engages a shoulder within said wall.

29. Apparatus according to any of claims 1 to 28, wherein said sphere canister comprises two separable portions.

30. Apparatus for cementing a string of downhole tubular members in a borehole, the apparatus comprising:

an upper member;

a first launching unit including a first dart canister and a first dart valve member disposed within a first modular member;

a second launching unit including a second dart canister and a second dart valve member disposed with a second modular member; and,

a third launching unit including a sphere canister and a sphere valve member disposed within a lower member.

31. Apparatus according to claim 30, wherein said second launching unit is interchangeable with said first launching unit.

32. Apparatus according to claim 30 or claim 31, wherein said valve members are interchangeable.

33. Apparatus according to any of claims 30 to 32, wherein the arrangement is such that one or more further launching units may be added between said upper member and said third launching unit.

34. A method for dropping devices from an apparatus into a borehole, the method comprising:

preloading a dart device and a sphere device within a bore of the apparatus;

flowing fluid through the bore;

isolating the dart device and the sphere device from the flowing fluid when the apparatus is in a holding position;

dropping the sphere device into the borehole while the fluid is flowing through the bore; and,

dropping the dart device into the borehole while the fluid is flowing through the bore.

35. An assembly for cementing a string of tubulars in a borehole, the assembly comprising:

a swivel; and,

a cementing manifold with internal bypass means.

36. An assembly according to claim 35, further comprising a flag sub.

37. An assembly according to claim 35 or claim 36, further comprising a top drive unit for rotating a drill string through said swivel.

38. An assembly according to any of claims 35 to 37, wherein said swivel further comprises:

an outer stationary member with cement connections; and,

an inner rotating member with a bore therethrough;

wherein said outer stationary member is formed from one piece.

39. An assembly according to claim 38, wherein said swivel further comprises angled ports extending between said cement connections and said bore.

40. An assembly according to claim 38 or claim 39, further including seals disposed between said outer stationary member and said inner rotating member.

41. An assembly according to claim 40, wherein seals are disposed within a shoulder of the outer stationary member.

42. An assembly according to claim 40 or claim 41, wherein said inner rotating member includes a common diameter in the area where the seals are disposed.

43. A swivel for cementing a string of tubulars in a borehole, the swivel comprising:

an outer stationary member with cement connections; and,

an inner rotating member with a bore therethrough;

wherein said outer stationary member is formed from one piece.

44. A swivel according to claim 43, wherein said swivel further comprises angled ports extending between said cement connections and said bore.

45. An assembly according to claim 43 or claim 44, further including seals disposed between said outer stationary member and said inner rotating member.

46. An assembly according to claim 45, wherein seals are disposed within a shoulder of the outer stationary member.

47. An assembly according to claim 45 or claim 46, wherein said inner rotating member includes a common diameter in the area where the seals are disposed.

48. Apparatus according to claim 1, further including a flow by-pass around said sphere valve member through said bore.

49. Apparatus according to claim 17, wherein said plug is cylindrical.

50. Apparatus according to claim 17, wherein said plug is spherical.

51. Apparatus for cementing a string of tubulars in a borehole, substantially in accordance with any of the examples as hereinbefore described with reference to and as illustrated by the accompanying drawings.

52. A method for dropping devices from an apparatus into a borehole, substantially in accordance with any of the examples as hereinbefore described with reference to and as illustrated by the accompanying drawings.

53. A swivel for cementing a string of tubulars in a borehole, substantially in accordance with any of the examples as hereinbefore described with reference to and as illustrated by the accompanying drawings.

The Patent Office

INVESTOR IN PEOPLE

Application No:	GB 0217887.9	**Examiner:**	Nicholas Mole
Claims searched:	1-29, 48-50	**Date of search:**	6 November 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): E1F (FJT, FJU, FJS, FKD, FKE, FKF, FKU)

Int Cl (Ed.7): E21B (33/13, 33/14, 33/16, 33/05, 23/00)

Other: Online: WPI EPODOC JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	US 6182752 B	(SMITH)	
X	US 4854383	(ARNOLD) see esp. figure 4	1-5, 17, 27, 50 at least
A	US 4345651	(AKKERMAN)	
X	US 3076509	(BURNS)	1, 17-18, 21, 23-24, 27, 49 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

THIS PAGE BLANK (USPTO)

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)